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EXCELENCIA SEVERO OCHOA

Task 3.2: Improved skill of seasonal prediction of water cycle and precipitation

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Improving skill of seasonal predictions (?)

By…

(1) Improving the model / prediction system
- Increasing the model resolution
- Land-surface initialisation

(2) Postprocessing
- Impose empirical relationships e.g. to NAO
- Combining different models/prediction systems
- Bias correction

(1) Improving the model / prediction system

- initialization of the model with realistic soil moisture conditions (as opposed to climatological mean)
- increase the model atmosphere and ocean resolutions

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Improvements from initializing soil moisture

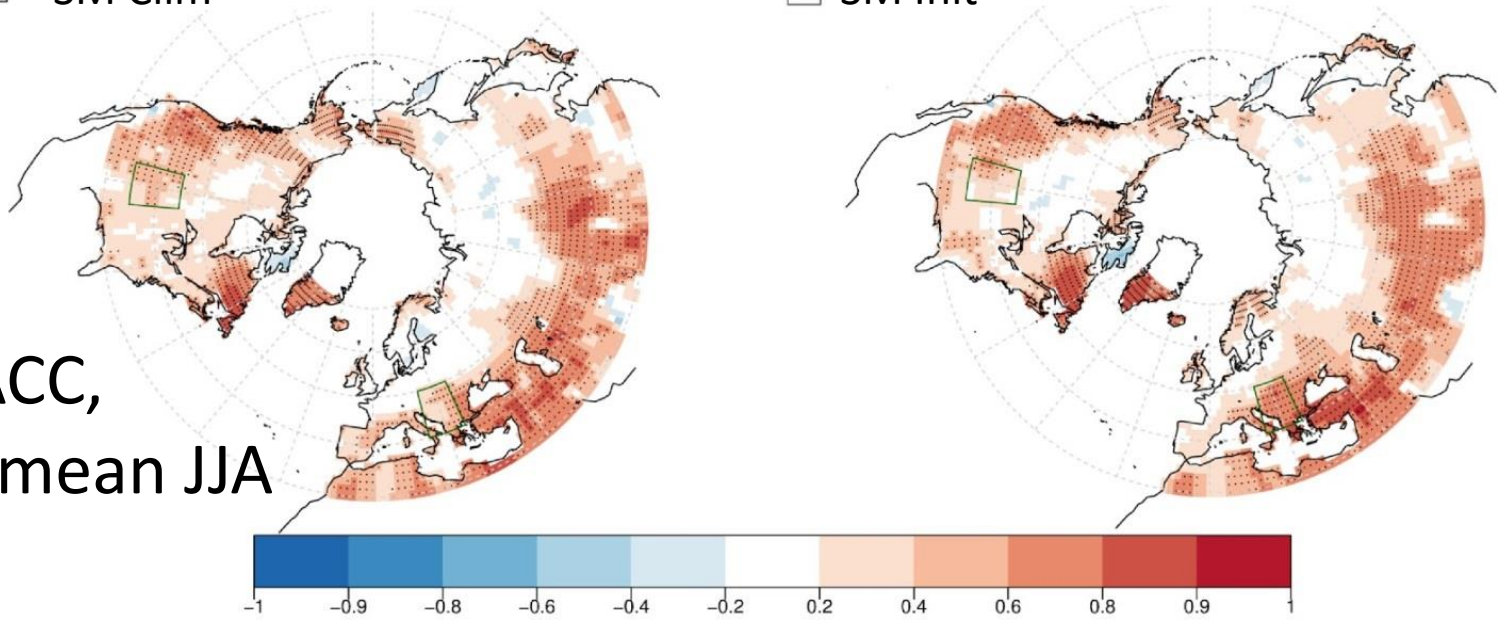
Twin sets of experiments (SM_Clim, SM_init) for boreal summer (MJJA), 1992-2010
5 forecast systems: MPI-ESM, ECMWF System4, CNRM-CM5, EC-Earth v2.3 and GloSea5

Ardilouze, C. et al. (2017) Multi-model assessment of the impact of soil moisture initialization on mid-latitude summer predictability. Clim. Dyn., 49, 3959-3974.

Improvements from initializing soil moisture

a SM Clim

b SM Init



ACC,
Tmean JJA

Ardilouze et al. (2017) Clim. Dyn., 49, 3959-3974

Improvements from initializing soil moisture

a

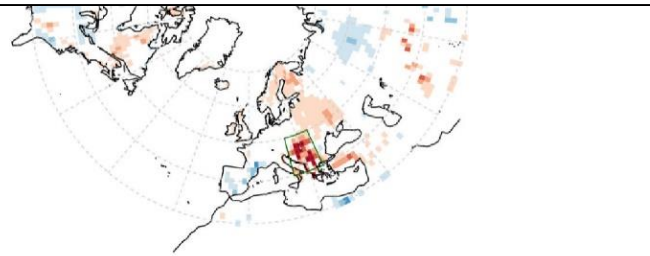
Tmean (JJA)

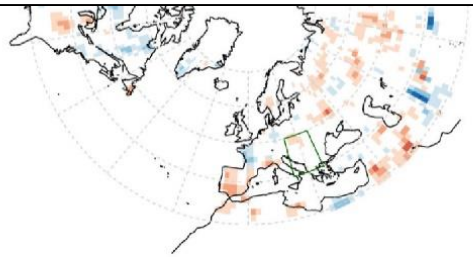
ACC (Init) – ACC (Clim)

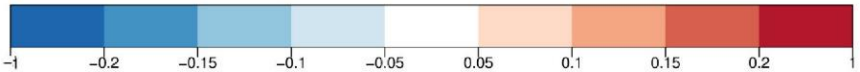
Precipitation (JJA)

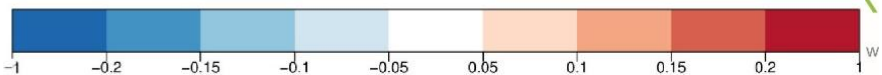
-> SM initialisation regionally improves temperature skill in SE Europe,

Generally poor skill for precipitation, improvements less conclusive



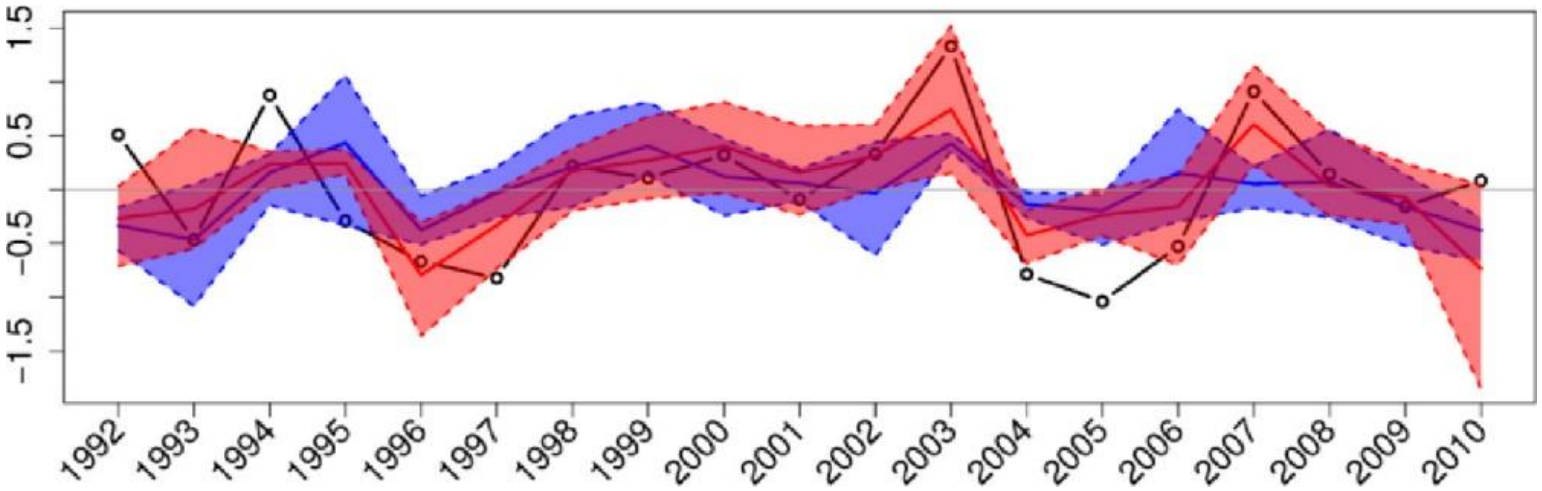






Improvements from initializing soil moisture

Tmean JJA, de-trended anomalies Balkan region



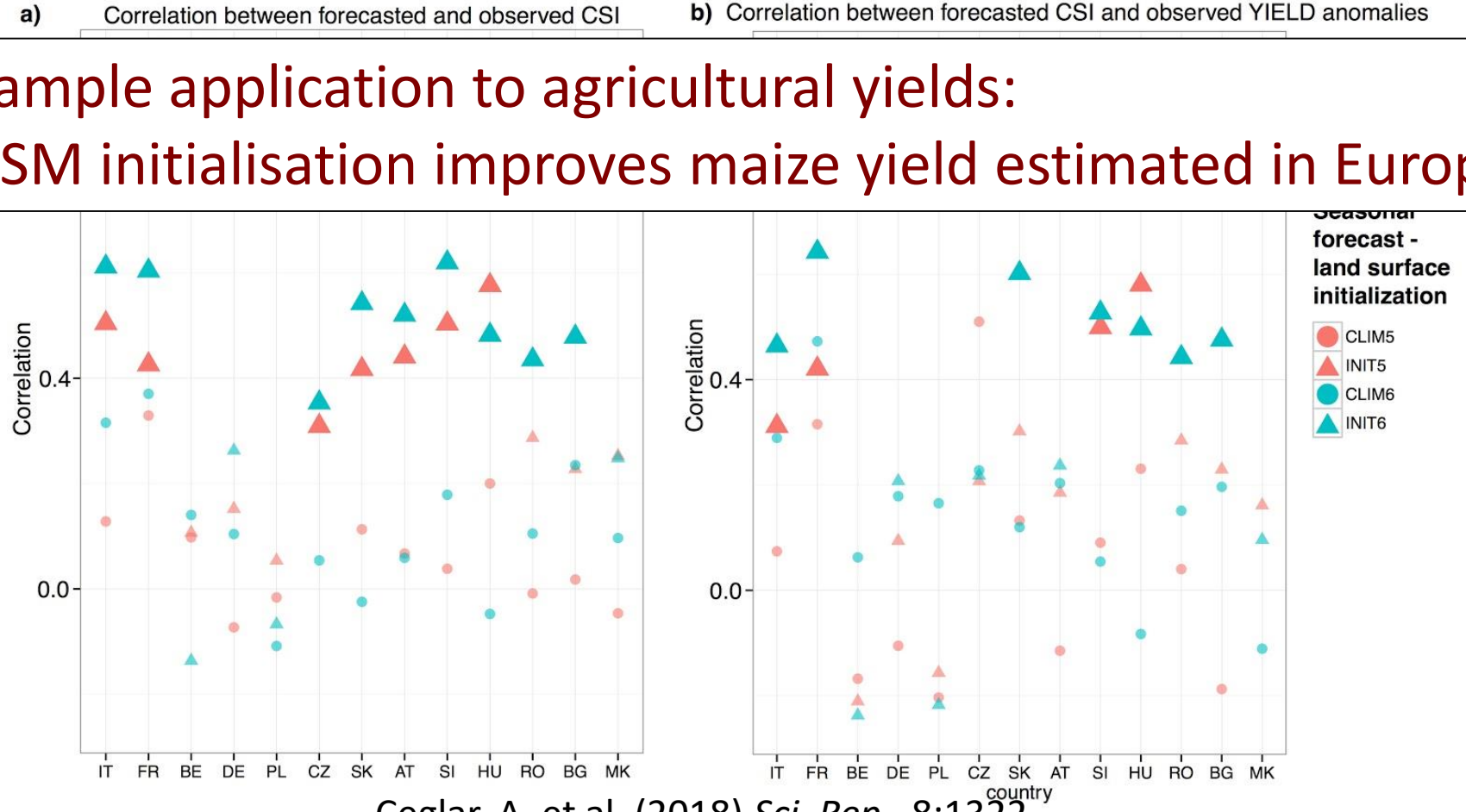
Black: ERA-Int, Red: SM_ini, Blue: SM_clim

-> SM initialisation regionally improves the simulated inter-annual variability of summer temperature

Ardilouze et al. (2017) Clim. Dyn., 49, 3959-3974

Impact of Soil Moisture Initialization on Seasonal Forecast of Maize Yield

Example application to agricultural yields:
-> SM initialisation improves maize yield estimated in Europe



Ceglar, A. et al. (2018) *Sci. Rep.*, 8:1322

Estimate maize yield anomalies (Y) based on combined stress index from SPEI and HDD

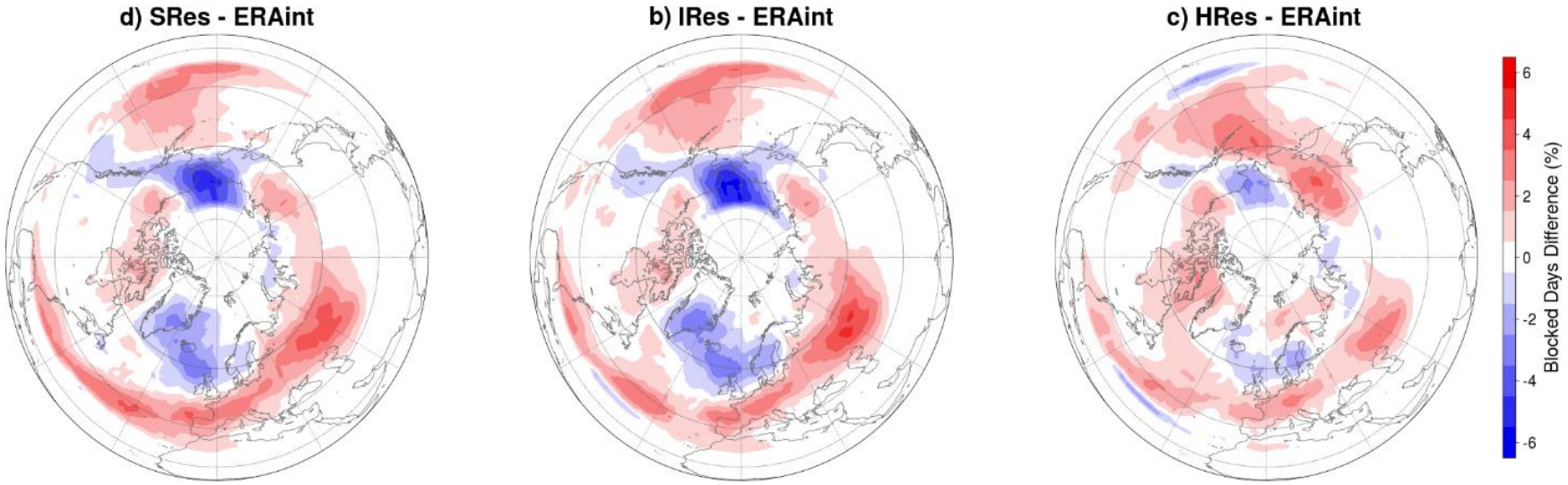
Improvements from increasing model resolution

SRes (standard):	atmosphere T255 (approx. 0.7° lat x lon), 91 vertical levels, ocean 1° (with refinements around equator and poles), 46 vertical layers
IRes (intermediate):	ocean resolution increased 0.25° , 75 vertical layers
HRes (high res):	atmosphere T511 (~0.35°), ocean 0.25° , 75 vertical layers

Prodhomme et al (2016) , J. Clim., 29, 9141-9162

Improvements from increasing model resolution

e.g. reduced bias in atmospheric blocking frequency

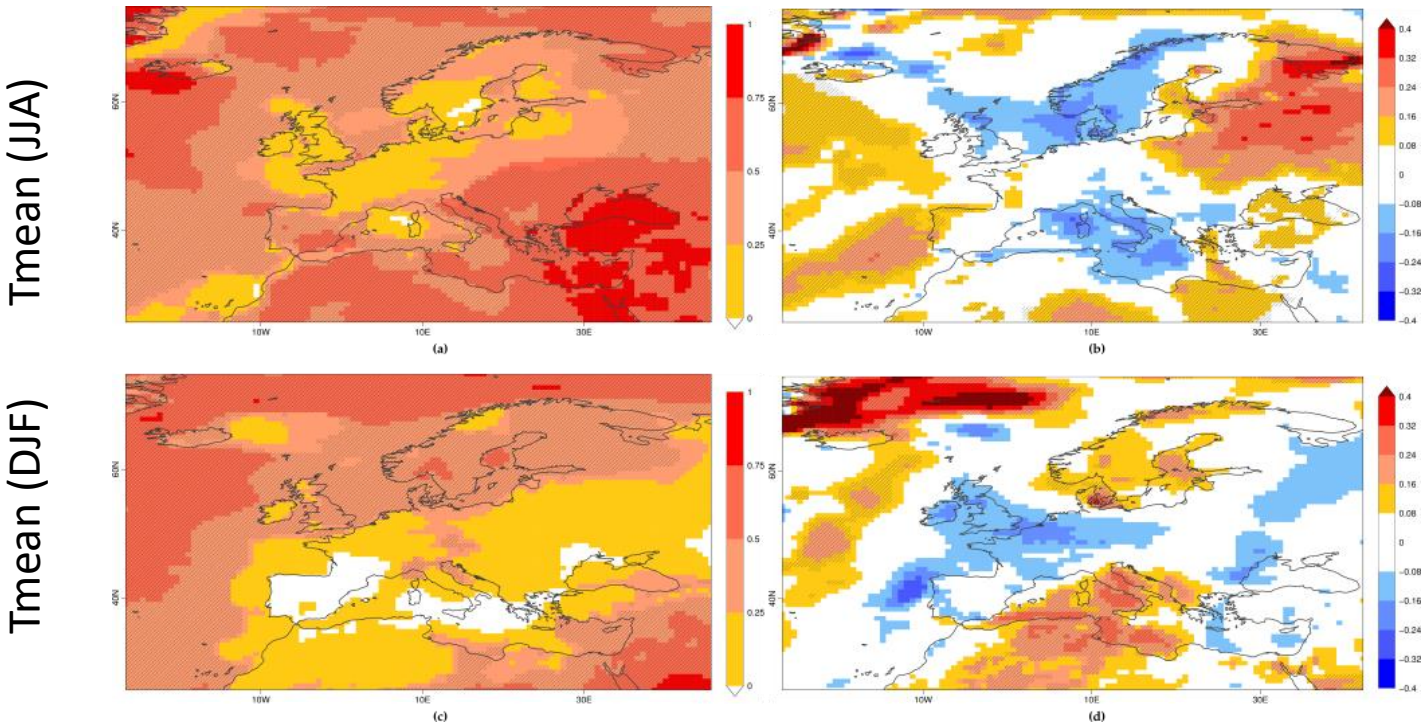


-> reduced bias in atmospheric blocking in the high-resolution simulations

Prodhomme et al (2016) , J. Clim., 29, 9141-9162

Improvements in next generation dynamical prediction system?

-> mixed pattern of regional skill improvements and reductions



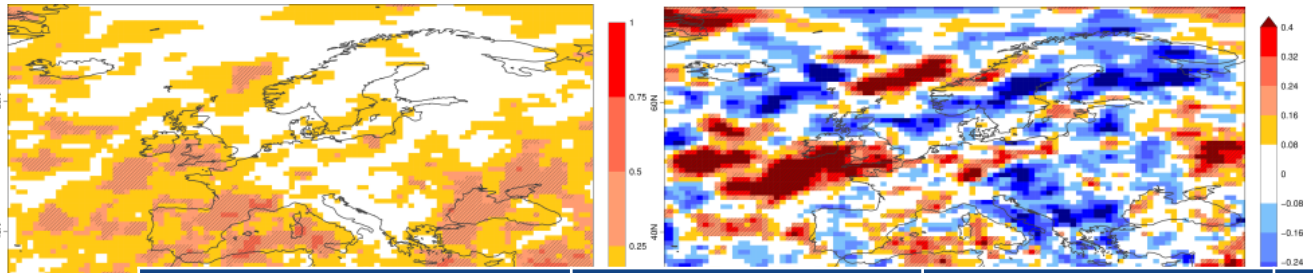
(Anomaly Correlation Coefficient, ACC; 1981-2015)

Improvements in next generation dynamical prediction system?

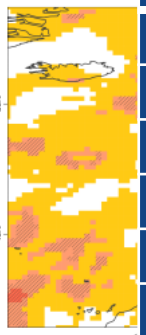
ECMWF System 5 versus System 4, e.g. Precipitation

System 5 | System 5 – System 4

Precip (JJA)



Precip (DJF)



	surface temperature		maximum surface temperature		precipitation	
	JJA	DJF	JJA	DJF	JJA	DJF
Bisagno	-0.11	0.02	-0.14	0.0	-0.15	0.03
Jucar	-0.01	0.01	-0.01	-0.07	-0.02	-0.27
Lake Como	-0.09	-0.05	-0.10	-0.07	0.03	0.01
Llobregat	-0.06	-0.04	-0.03	-0.06	-0.16	-0.09
Messara	**0.12**	-0.11	**0.13**	-0.13	-0.26	-0.20
Rhine-Meuse	0.02	-0.20	0.03	-0.20	0.14	0.08
Segura	-0.05	0.08	-0.07	-0.04	**0.25**	-0.16
Thames	0.02	-0.18	0.02	-0.16	0.29	0.10
Umealven	-0.16	0.08	-0.16	0.07	0.05	0.05

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(2) Skill improvements from processing the seasonal predictions model output

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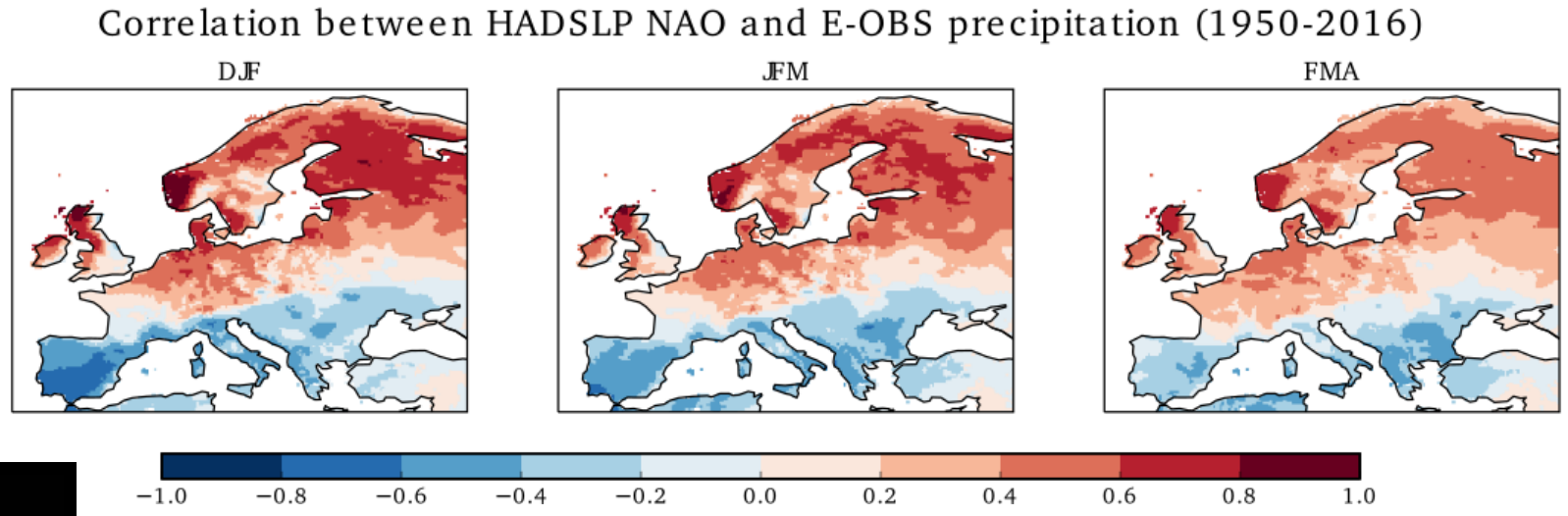
Imposing empirical (observed) NAO relationship

Idea:

- seasonal precipitation in Europe is correlated with NAO, and NAO can be skilfully predicted
- Models struggle with spatial patterns of NAO, and therefore local relationships
- Impose observed relationships to model-predicted NAO



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Courtesy: Nicky Stringer, Met Office

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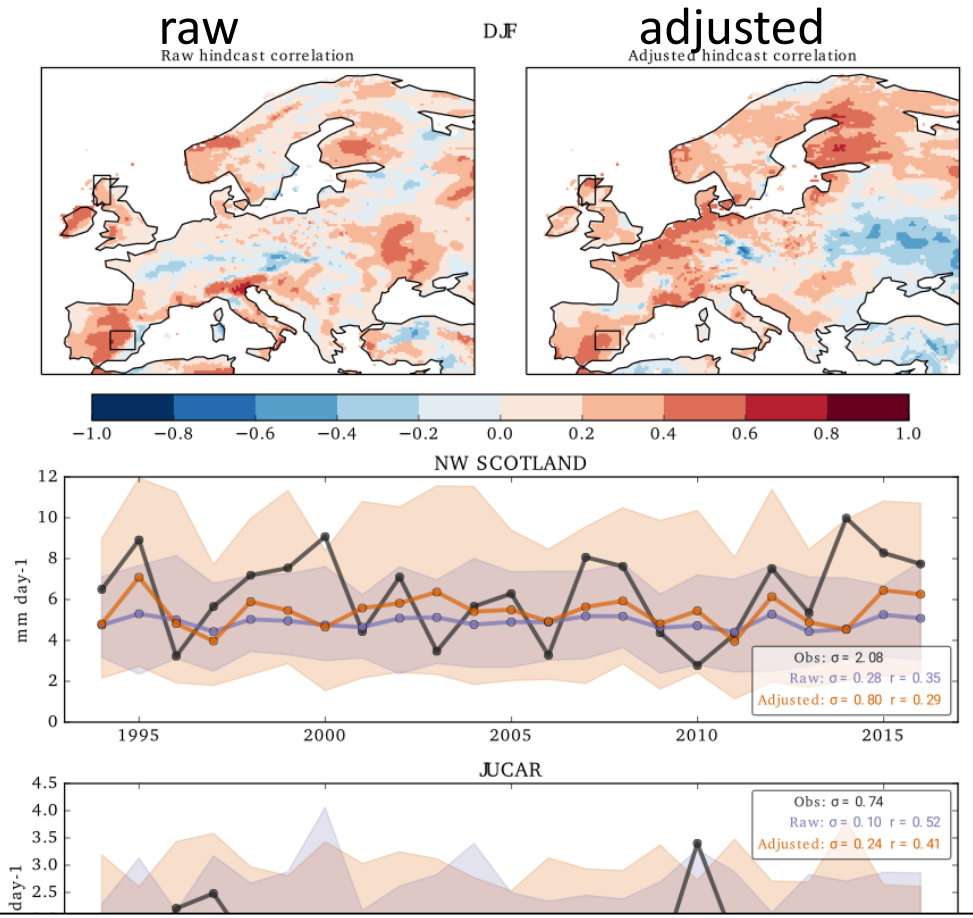
Imposing empirical (observed) NAO relationship

Correlation ensemble mean P vs E-Obs
(DJF, similar for JFM, FMA)

Regional time series of
seasonal mean precipitation
e.g. NW Scotland

Jucar

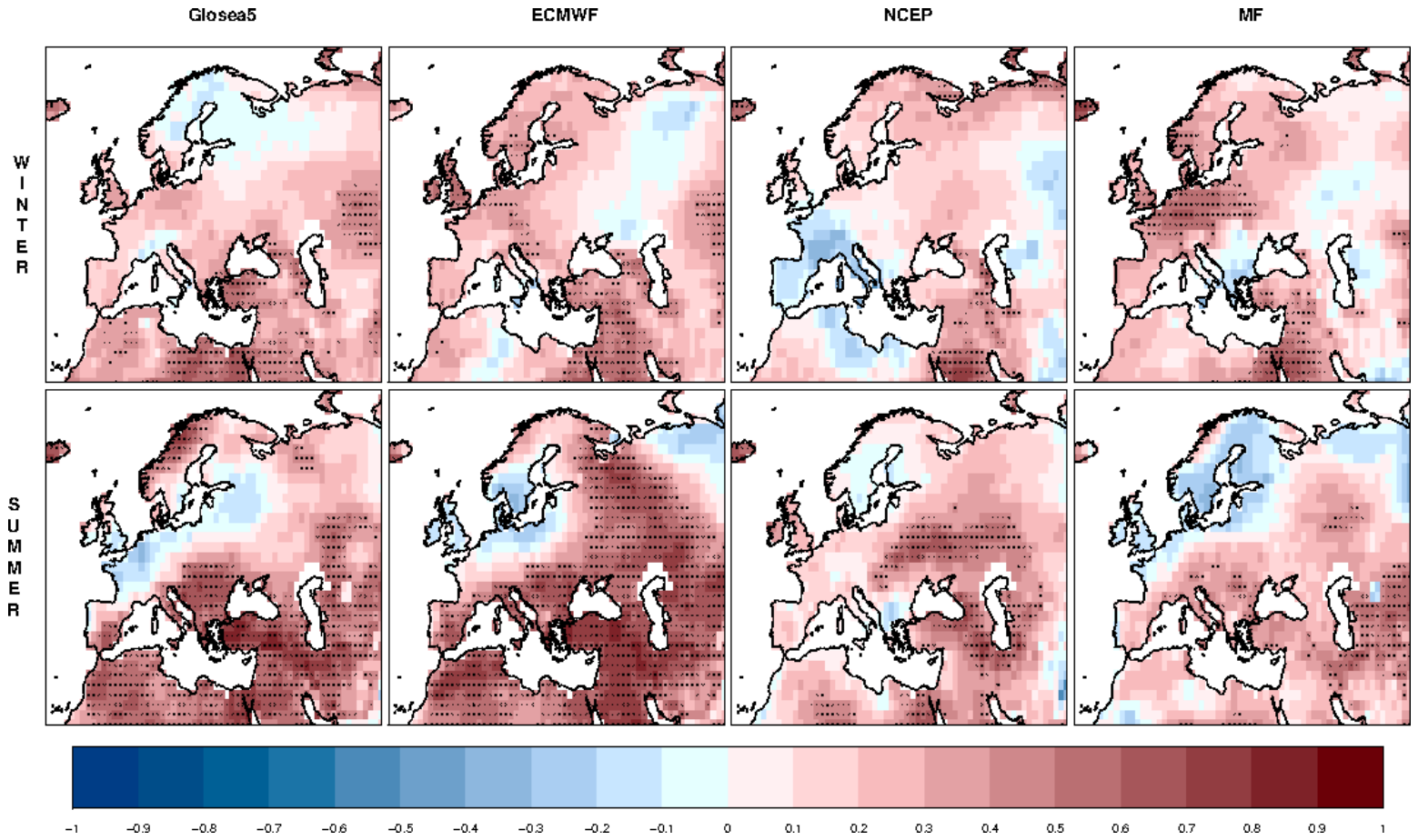


-> skill improvement (precipitation) in areas with positive correlations with NAO (i.e. NW Europe)

Courtesy: Nicky Stringer, Met Office

Multi-Model Skill Assessment

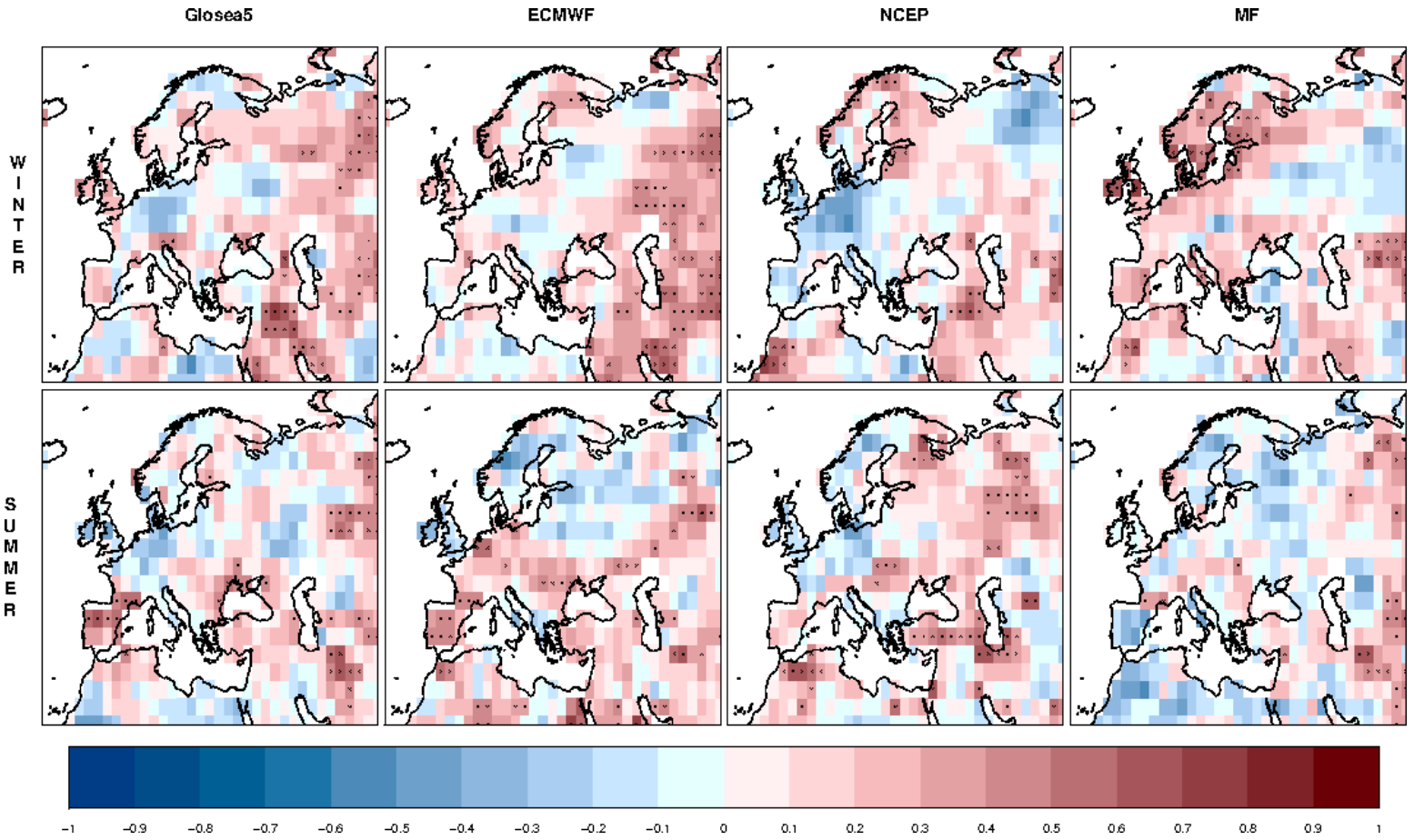
ACC seasonal temperature in different models



Mishra, N, C Prodhomme and V Guemas (2018), Climate Dynamics

Multi-Model Skill Assessment

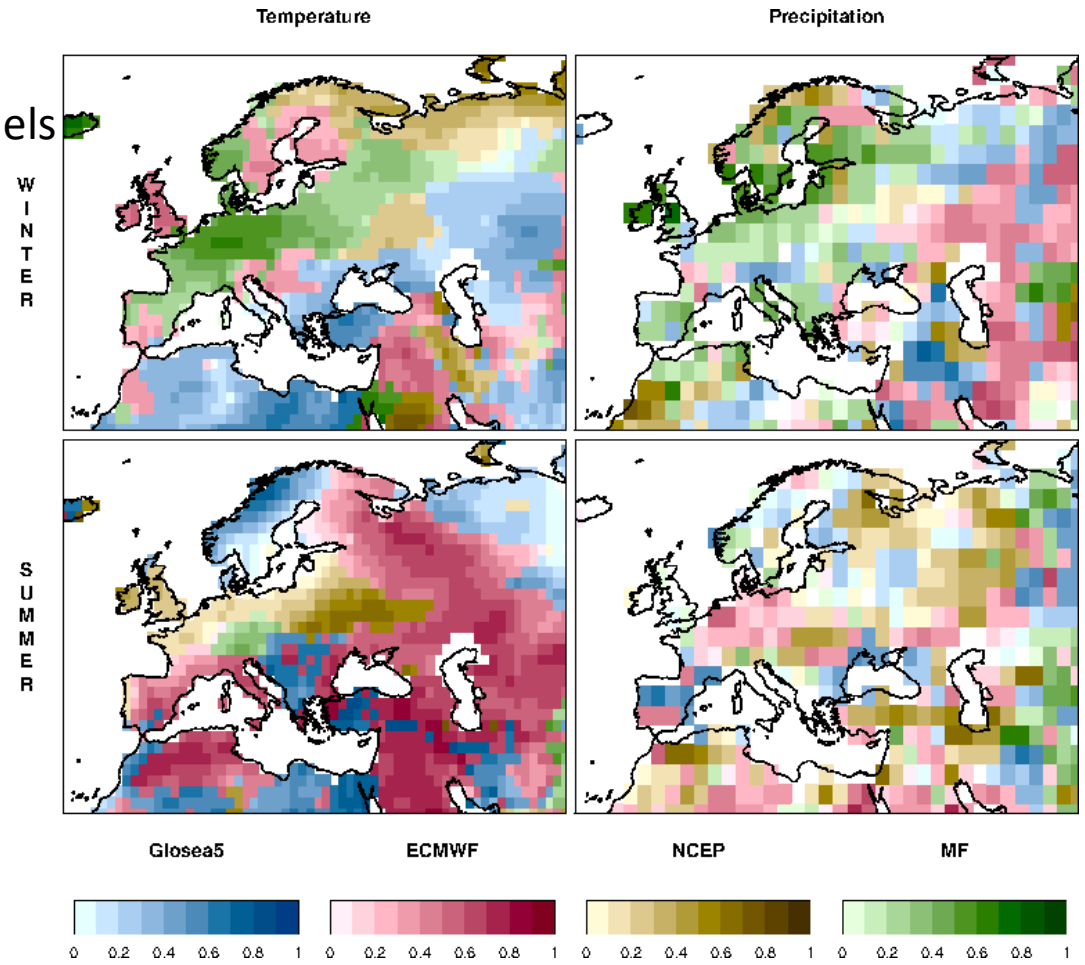
ACC seasonal precipitation in different models



Mishra, N, C Prodhomme and V Guemas (2018), Climate Dynamics

Multi-Model Skill Assessment

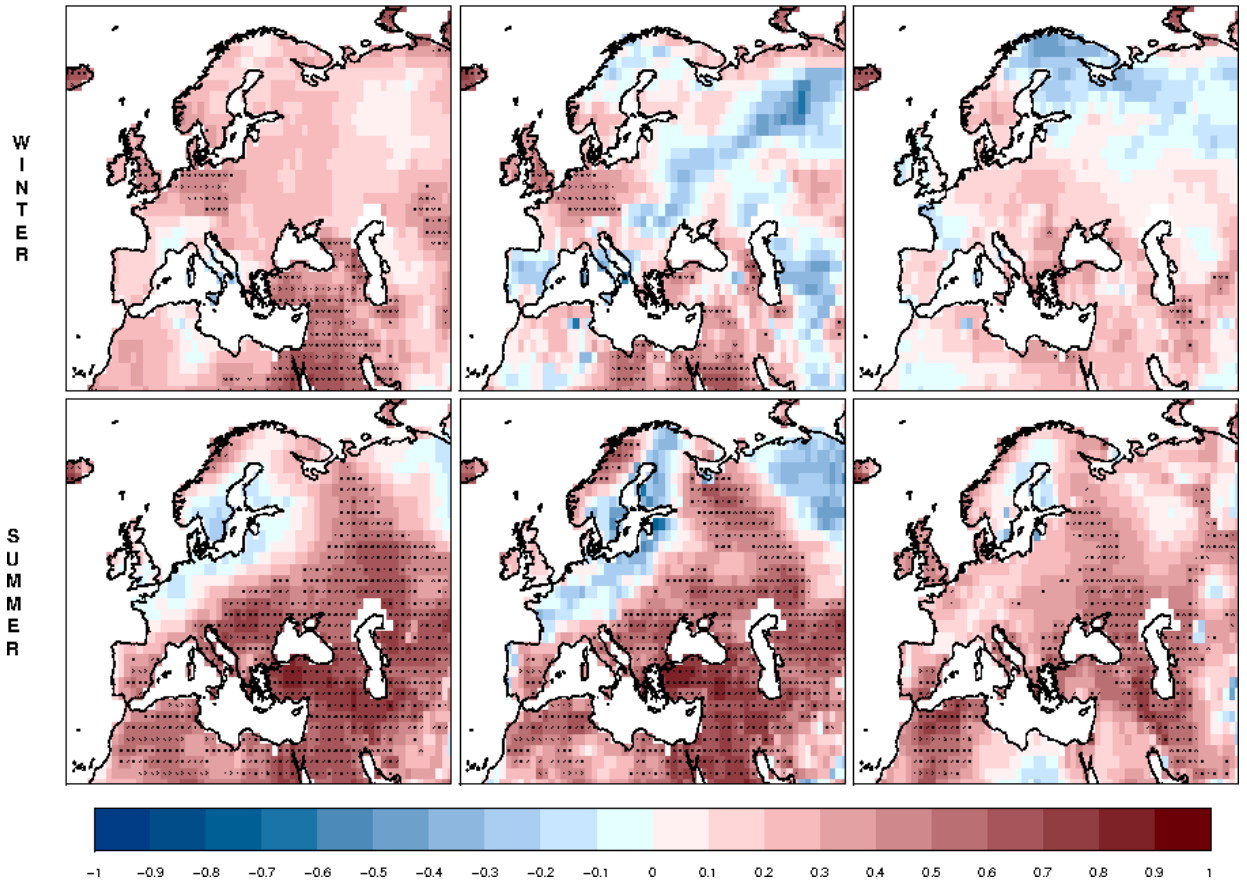
Maximum positive ACC among the four individual models



Mishra, N, C Prodhomme and V Guemas (2018), Climate Dynamics

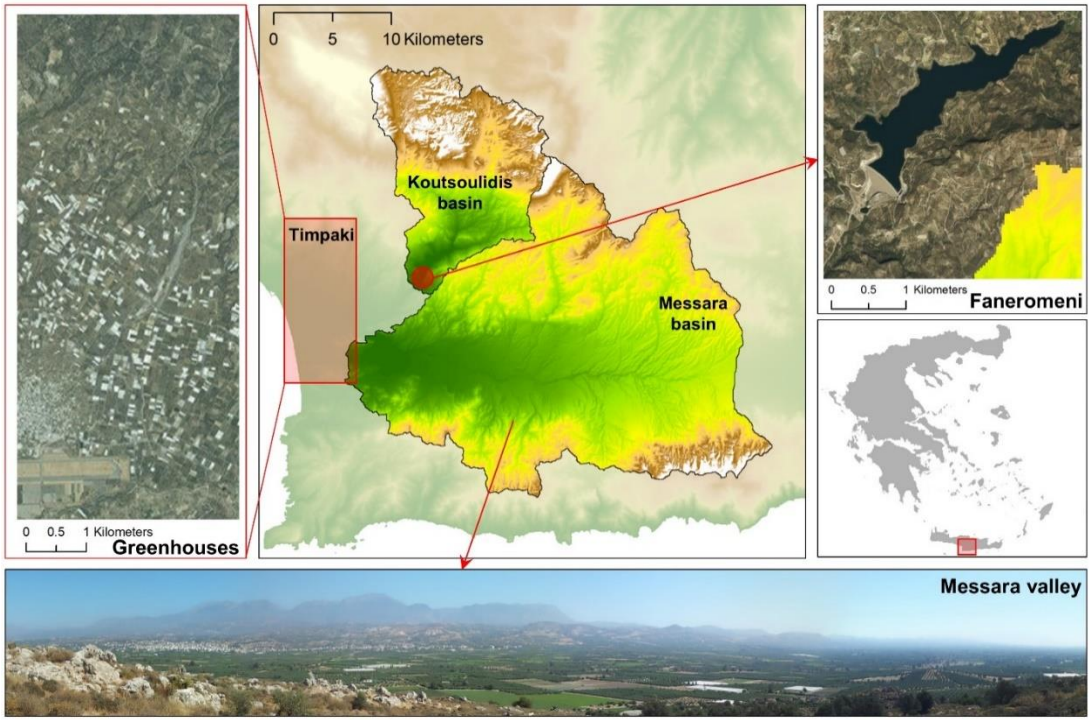
Multi-Model Skill Assessment

-> Ensemble average skill similar to best individual model, performance-based weighting shows no improvement



Mishra, N, C Prodhomme and V Guemas (2018), Climate Dynamics

Case study Koutsoulidis basin, Crete, Greece



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Courtesy: TUC

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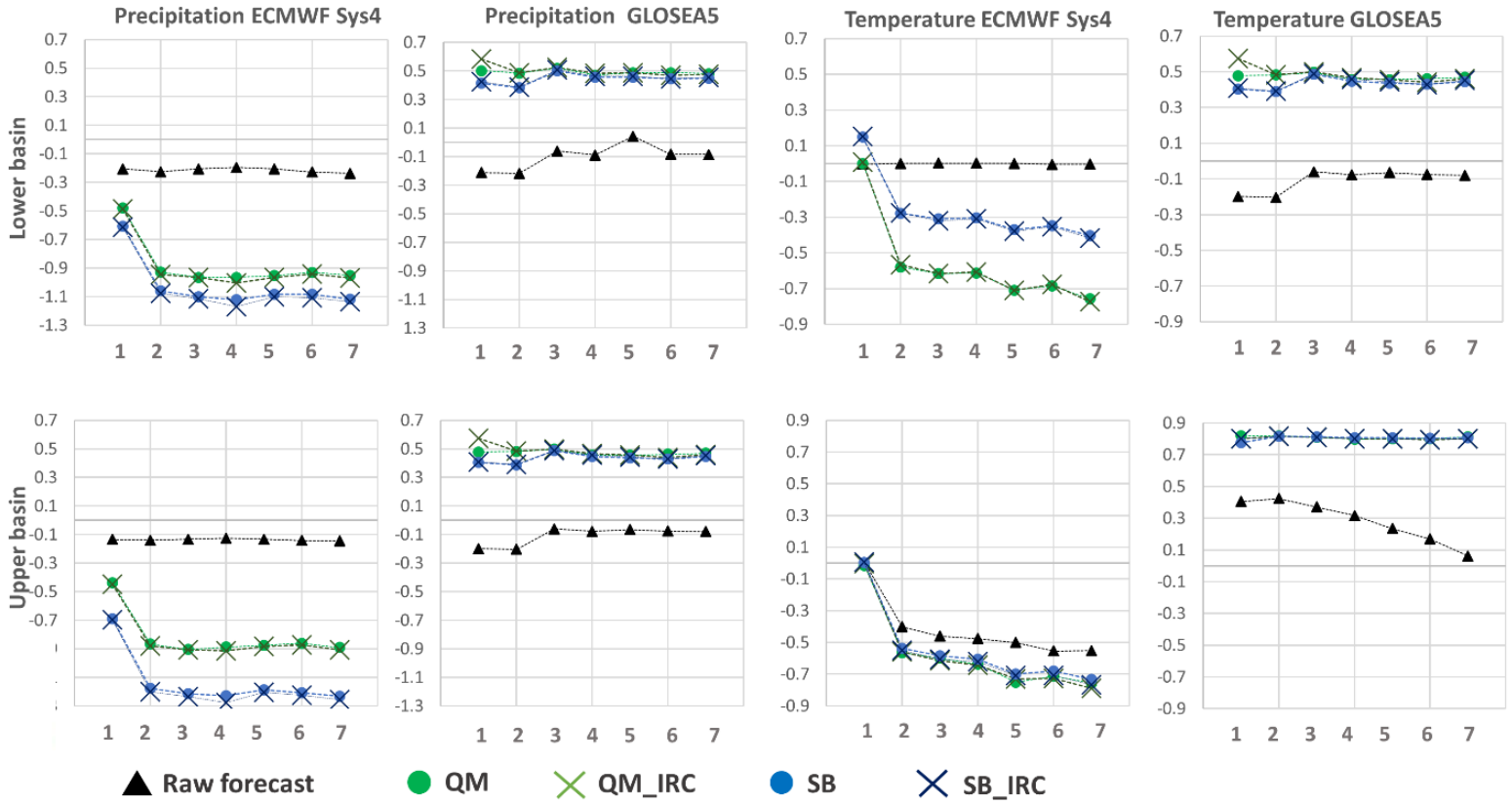
Case study Koutsoulidis basin, Crete, Greece

-> Mixed effect from Bias correction

Continuous Ranked Probability Skill Score (CPRSS) for monthly forecast data



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Courtesy: TUC

QM: quantile mapping
SB: Simple bias correction
IRC: Individual realisations correction

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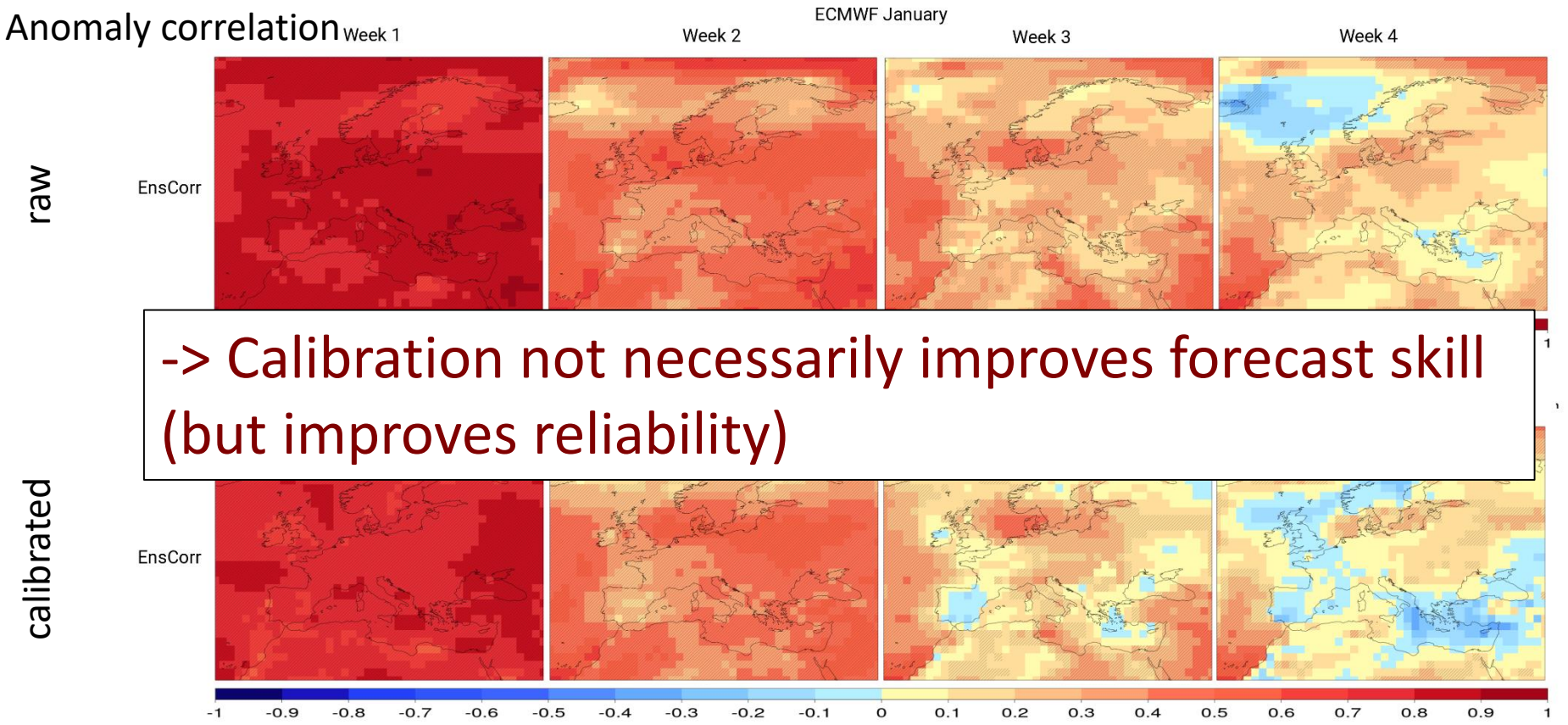
Effect of calibration on subseasonal predictions: e.g. T2m



-> Calibration not necessarily improves forecast skill (but improves reliability)

ECMWF monthly prediction system: 11 members, 20 yrs hincast (1996-2015)

Verification: ERA-Interim

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Summary

- Reasonable skill of seasonal predictions for temperature but generally low skill for precipitation
- Some regional (small) improvements of prediction skill by
  - Initialising observed soil moisture
  - Increasing the model resolution

- Smart processing of the model output can also improve skill
  - E.g. imposing observed empirical relationship between NAO and precipitation
  - Combining multiple models
  - Mixed results from bias correction, and calibration

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Thank you

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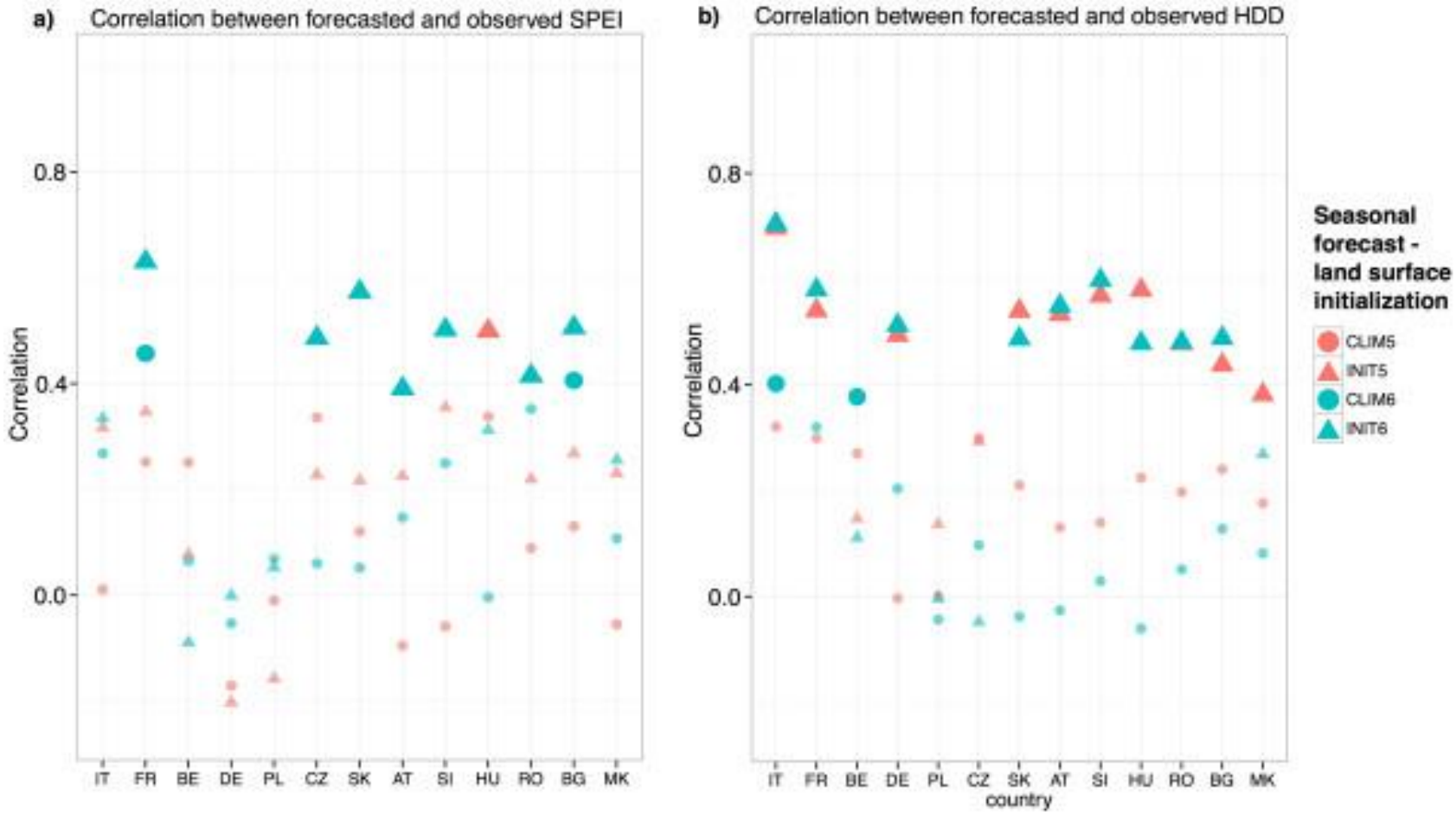
Impact of Soil Moisture Initialization on Seasonal Forecast of Maize Yield



Ceglar, A. et al. (2018) *Sci. Rep.*, 8:1322

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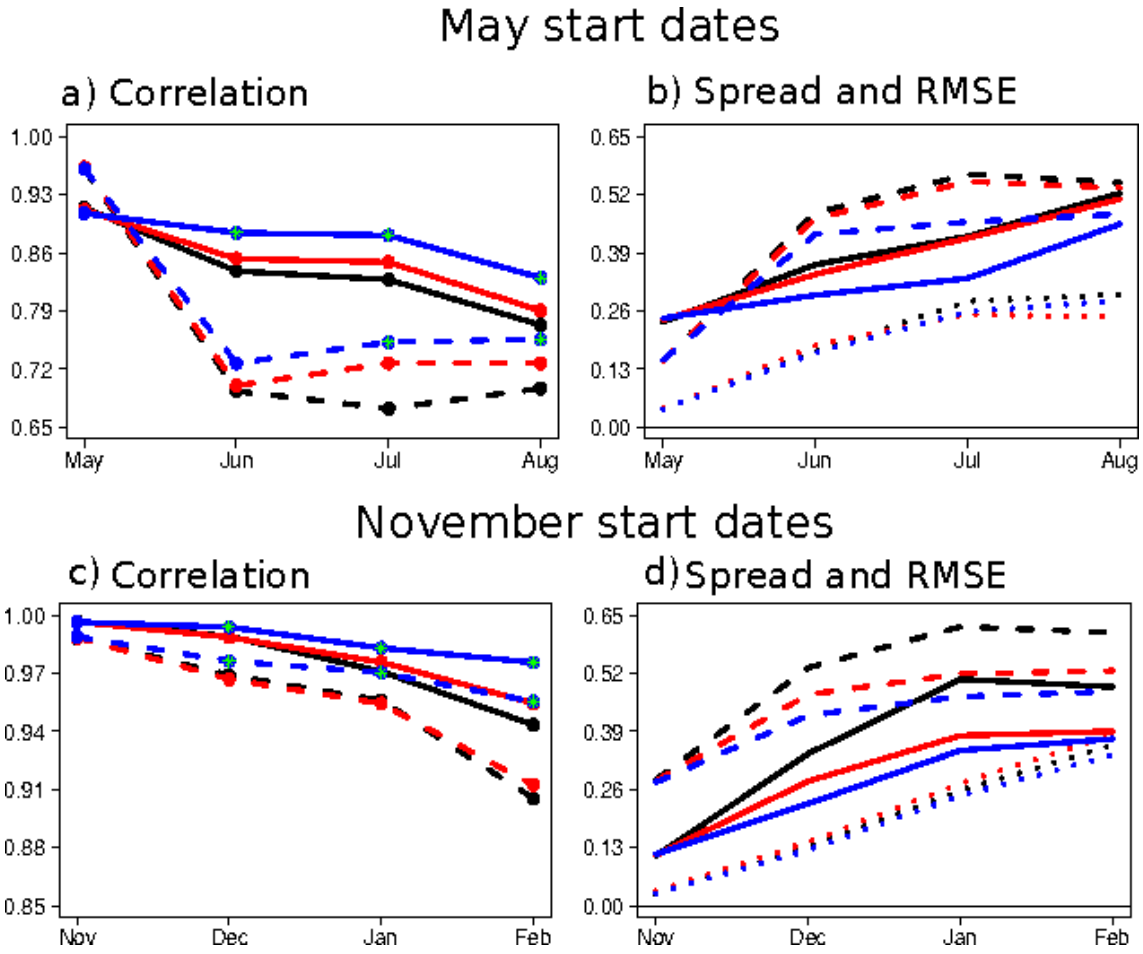
Improvements from increasing model resolution

e.g. improved ENSO predictions (Niño3.4)



SRes (black),
IRes (red),
HRes (blue)

Obs reference:
ESA (solid), ERSST (dashed)

Prodhomme et al (2016) , J. Clim., 29, 9141-9162

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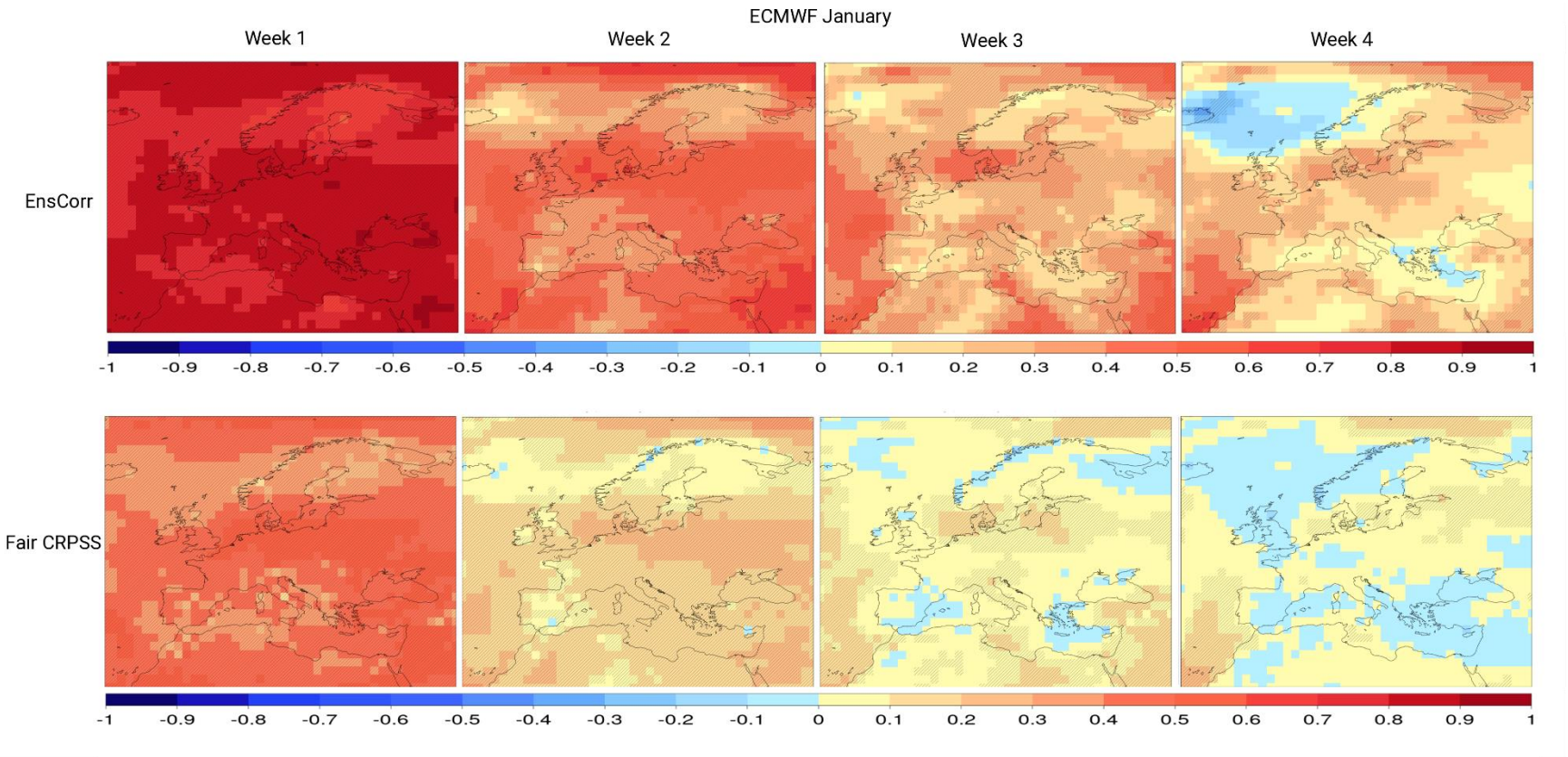
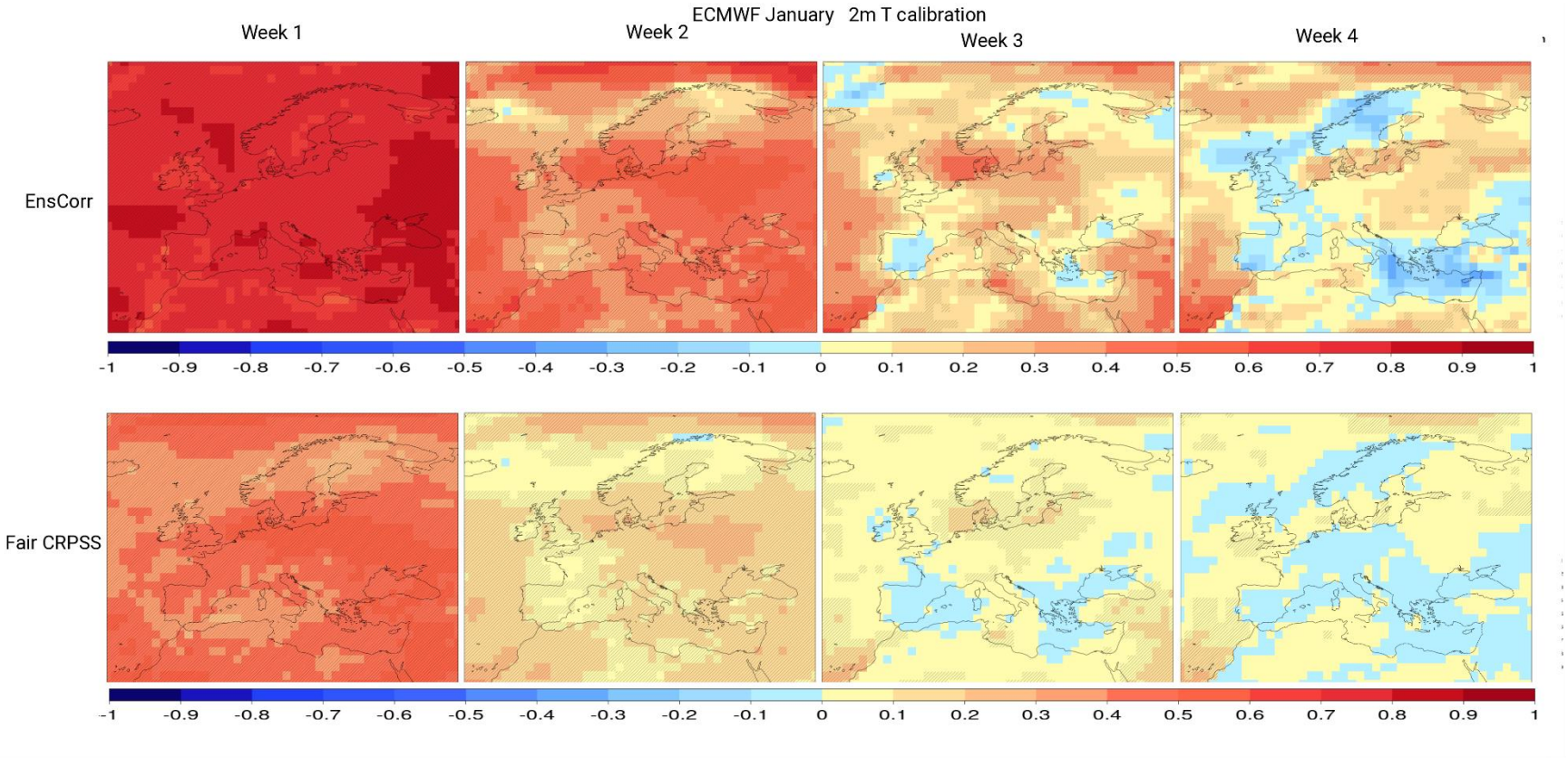
Subseasonal predictions: 2m T raw



ECMWF monthly prediction system: 11 members, 20 yrs hincast (1996-2015)

Verification: ERA-Interim

Effect of calibration on subseasonal predictions: e.g. T2m



ECMWF monthly prediction system: 11 members, 20 yrs hincast (1996-2015)
Verification: ERA-Interim
Calibration: Inflation method

Calibration improves reliability, not forecast skill